

Using Gamma-Ray Bursts to Probe the Metal Enrichment History of the Universe

Completed Technology Project (2018 - 2020)



Project Introduction

Galaxies are not "Island Universes" but rather they are complex "Galactic Ecosystems", where gas and metals flow in and out. The circumgalactic medium is the diffuse gas that surrounds galaxies out to ~ 150 kpc and lies at the nexus of accretion flows onto galaxies and outflows out of galaxies. The CGM is a major reservoir of metals and it is therefore imperative to study the CGM out to the dawn of galaxy formation (redshift $z \sim 7$) to get a better handle on the metal enrichment history of the universe. Most of the constraints on the CGM have so far been derived from the observations of bright distant QSOs used as backlight sources to probe the CGM material between us and the quasars. Here instead, we use the bright flashes of light associated with gamma-ray bursts (GRBs). The GRB method offers a number of key advantages over the traditional QSO method such as, further reach into the early universe, easy to analyze spectral signatures and most importantly, the opportunity to probe the host galaxy and its surrounding CGM together. Another unique aspect of the proposed study is our data set. We will combine (1) high-S/N ground-based UV-optical spectra of 169 GRB afterglows spanning a redshift range from 1 to 6.7 with (2) multi-wavelength photometric and spectroscopic data on the host galaxies of these GRBs. This is the culmination of a 10-year effort and represents the largest set of such data ever assembled. The analysis of these data will follow relatively straightforward and time-tested traditional techniques. First, the strengths and profiles of the CGM absorption lines imprinted onto the GRB afterglow spectra will be measured and compared to derive the kinematics, ionization state, and metallicity of the CGM. Next, these CGM properties will be compared with the stellar masses and star formation rates of the GRB host galaxies derived from (2) to better understand the role of the galaxy in driving the transport processes of metals in the CGM, as a function of cosmic time, and thus, probe the overall metal enrichment history of the universe. We will further use ionization modeling to extract tight constraints on physical properties and mass of metals in the CGM. This project is directly relevant to NASA's goals under the Cosmic Origins theme. The results derived from our large data set will empower future simulations and observations geared towards galaxy formation, feedback processes and their evolution along the timeline of the universe.



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Organizational Responsibility

Responsible Mission Directorate:

Science Mission Directorate (SMD)

Lead Organization:

University of Maryland-College Park (UMCP)

Responsible Program:

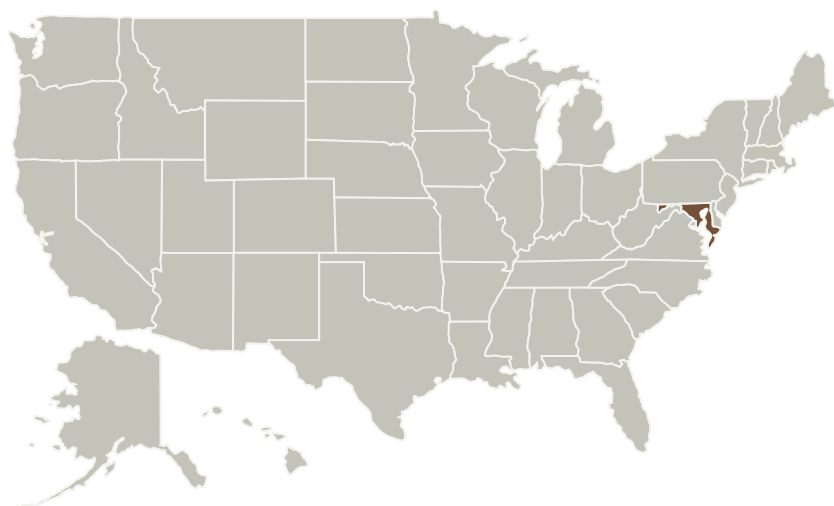
Astrophysics

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Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
University of Maryland-College Park(UMCP)	Lead Organization	Academia Asian American Native American Pacific Islander (AANAPISI)	College Park, Maryland

Primary U.S. Work Locations

Maryland

Project Management

Program Manager:

Joe Hill-kittle

Principal Investigator:

Sylvain Veilleux

Co-Investigators:

Pradip R Gatkine

Stephanie M Swann

Technology Areas

Primary:

- TX11 Software, Modeling, Simulation, and Information Processing
 - └ TX11.2 Modeling
 - └ TX11.2.4 Science Modeling

Target Destination

Outside the Solar System